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ABSTRACT

APL (A Programing Language), a computer language used thus far largely for mathematical and scientific applications, can be used to tabulate a survey. Since this computer application can be appreciated by social scientists as well as mathematicians, it serves as an invaluable pedagogical tool for presenting APL to nonscientific users. An illustrative survey and the tabulated results are presented. (Author/PF)

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THE SURVEY

An Interdisciplinary Computer Application

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1. Introduction

The major applications of APL have been mathematical and scientific. Tabulating the results of a survey is a computer application which is of particular interest to the social sciences and other disciplines which survey human populations. In addition to its general interest, the tabulation of a survey demonstrates many of the powerful features of APL.

2. Tabulation

As an illustration, consider the survey in Figure 1. The function INITIALIZE in Figure 2 initializes the global variables which are used in this workspace. The function START in Figure 2 is used to input the coded responses of an individual respondent while the function STORE catenates these responses to the previous responses. It might be worth mentioning that when these functions were designed, it was anticipated that students would be inputting the data as part of a course project. As such, this is not the most efficient method for inputting data. However, it is a relatively simple task to redesign the programs to meet different requirements. After the responses have been entered, the function RESULTS in Figure 3 returns the tabulated results.

In any poll it is often desirable to determine how different groups or subsets respond to the same question. In our example, the comparison of the answers to questions four and five for those who voted for the President with those who did not might be of special interest to the conductor of the survey. The function CROSSΔTAB in Figure 4 performs such a cross-tabulation. Again, since these functions were designed for student assignments, it was decided to store the results in a workspace so that it is possible to get a quick response on CROSSΔTAB. For an extensive survey, it might be advisable to use files.

3. Power of APL

The responses are assigned to T which is a Boolean vector.

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However, displaying the responses as a three dimensional array gives a better representation of the responses.

Figure A

```
      ρT
120

        4 5 6ρT
1 0 0 0 0 0
0 1 0 0 0 0
0 0 1 0 0 0
0 0 0 1 0 0
0 0 0 0 1 0

1 0 0 0 0 0
1 0 0 0 0 0
1 0 0 0 0 0
1 0 0 0 0 0
1 0 0 0 0 0

1 0 0 0 0 0
1 0 0 0 0 0
1 0 0 0 0 0
0 0 0 0 0 1
0 0 0 0 0 1

0 1 0 0 0 0
0 1 0 0 0 0
0 0 0 0 1 0
0 0 1 0 0 0
0 0 1 0 0 0
```

Each 5 x 6 matrix corresponds to the responses of an individual respondent. The sum of all the respondents is obtained by executing:

Figure B

```
    +/[1]4 5 6ρT
3   1  0  0  0  0
2   2  0  0  0  0
2   0  1  0  1  0
1   0  1  1  0  1
1   0  1  0  1  1
```

Lines 1 and 4 of the function STORE are particularly powerful and merit closer examination.

Figure C

```
      ∇STORE[⎕]∇
     ∇ STORE;V;S
[1]    →((⍴⍴D)∧(∧/D∈⍳P))/L1
[2]    →0,⍴⍞←'CHECK YOUR DATA. THERE IS AN ERROR.'
[3]  L1:V←(Q×P)⍴0
[4]    S←D+P×0,⍳(Q-1)
[5]    V[S]←V[S]+1
[6]    T←T,V
[7]    'RESPONDENT ';(⍴T)÷Q×P
[8]    'NOW EXECUTE: )SAVE ',W
     ∇
```

Line 1 checks the validity of the input. That is, it determines whether the dimension of the input is correct and whether the input is an acceptable response.

Line 4 calculates the indices of the coded responses. In Line 5, the number 1 is added to the positions which correspond to these indices. For the last respondent, the steps are:

Figure D

```
      D
2 2 5 3 3

      TAB←STORE←4
      STORE
STORE[4] 2  8  17  21  27
RESPONDENT 5
NOW EXECUTE: )SAVE SURVEYS
```

The variable D contains the coded responses 2 2 5 3 3 of the last respondent. The corresponding indices are 2 8 17 21 27.

The translation of the coded responses into indices can be accomplished in a single line in APL. In other programming languages, this translation would require a loop.

The functions CHANGE, DELETE and INSERT in Figure 6 may be used to edit the input. The conciseness and usefulness of these functions is another illustration of the power and elegance of APL.

4. Summary

It has been suggested that the ideal way to learn a computer programming language is to use it to solve problems. Tabulating the results of a survey is a computer application which can be appreciated by social scientists as well as mathematicians. Because of its universal appeal, the survey is an invaluable pedagogical tool for presenting APL to non-scientific users.

Figure 1

1. Did you vote for President Nixon in the last election?

   1- Yes 2- No 3- Did not vote

2. How do you rate the President's performance in foreign affairs?

   1- Very good 2- good 3- average 4- poor

   5- very poor

3. How do you rate the President's performance in domestic affairs?

   1- Very good 2- good 3- average 4- poor

   5- very poor

4. How would you rate the President's handling of Watergate?

   1- Very good 2- good 3- average 4- poor

   5- very poor

5. In your opinion, what is the probability that the President will be impeached?

   1- Very low 2- low 3- 50-50 4- high

   5- very high

Figure 2

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```
      )LOAD 50 SURVEYS
SAVED  14.29.10 03/19/74

      INITIALIZE
HOW MANY ITEMS IN THIS SURVEY?
⎕:
      5
WHAT IS THE MAXIMUM NUMBER OF RESPONSES TO ANY ITEM OR QUESTION?
PROVIDE FOR NO RESPONSE, I.E., IF THE EXPECTED RESPONSES
ARE YES OR NO OR NO OPINION; THE CODING IS 1-YES 2-NO
3- NO OPINION 4-NO RESPONSE.
⎕:
      6
WHAT IS THE NAME OF THE WORKSPACE?
SURVEYS

      START
ENTER THE REPLIES  OF ONE RESPONDENT. TYPE → ON A SEPARATE LINE WHEN FINISHED.
⎕:
      1 2 3 4 5
⎕:
      →

      STORE
RESPONDENT 1
NOW EXECUTE: )SAVE SURVEYS

      START
ENTER THE REPLIES  OF ONE RESPONDENT. TYPE → ON A SEPARATE LINE WHEN FINISHED.
⎕:
      1 1 1 1 1
⎕:
      →

      STORE
RESPONDENT 2
NOW EXECUTE: )SAVE SURVEYS

      START
ENTER THE REPLIES  OF ONE RESPONDENT. TYPE → ON A SEPARATE LINE WHEN FINISHED.
⎕:
      1 1 1 6 6
⎕:
      →
      STORE
RESPONDENT 3
NOW EXECUTE: )SAVE SURVEYS

      START
ENTER THE REPLIES  OF ONE RESPONDENT. TYPE → ON A SEPARATE LINE WHEN FINISHED.
⎕:
      2 2 5 3 3
⎕:
      →

      STORE
RESPONDENT 4
NOW EXECUTE: )SAVE SURVEYS
```

Figure 3

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RESULTS
RESPONDENTS 4

ITEM 1

	1	2	3	4	5	6
FREQUENCIES	3	1	0	0	0	0
PERCENT	0.75	0.25	0.00	0.00	0.00	0.00

MEAN 1.25
SD 0.50

ITEM 2

	1	2	3	4	5	6
FREQUENCIES	2	2	0	0	0	0
PERCENT	0.50	0.50	0.00	0.00	0.00	0.00

MEAN 1.50
SD 0.57

ITEM 3

	1	2	3	4	5	6
FREQUENCIES	2	0	1	0	1	0
PERCENT	0.50	0.00	0.25	0.00	0.25	0.00

MEAN 2.50
SD 1.91

ITEM 4

	1	2	3	4	5	6
FREQUENCIES	1	0	1	1	0	1
PERCENT	0.25	0.00	0.25	0.25	0.00	0.25

MEAN 2.66
SD 1.52

ITEM 5

	1	2	3	4	5	6
FREQUENCIES	1	0	1	0	1	1
PERCENT	0.25	0.00	0.25	0.00	0.25	0.25

MEAN 3.00
SD 2.00

Figure 4

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```
      CROSSTAB
WHAT IS THE ROW AND COLUMN INDEX OF THE ITEM YOU WISH TO CROSS-TAB?
?:
      1 1
AGAINST WHAT ITEMS OR QUESTIONS DO YOU WISH TO COMPARE IT?
?:
      1 4 5

FREQUENCIES

      ITEM          1          2          3          4          5          6

         1          3          0          0          0          0          0
                 1.00       0.00       0.00       0.00       0.00       0.00

         4          1          0          0          1          0          1
                 0.33       0.00       0.00       0.33       0.00       0.33

         5          1          0          0          0          1          1
                 0.33       0.00       0.00       0.00       0.33       0.33


DO YOU WISH TO PERFORM ANOTHER CROSS-TAB?
YES
WHAT IS THE ROW AND COLUMN INDEX OF THE ITEM YOU WISH TO CROSS-TAB?
?:
      1 2
AGAINST WHAT ITEMS OR QUESTIONS DO YOU WISH TO COMPARE IT?
?:
      1 4 5

FREQUENCIES

      ITEM          1          2          3          4          5          6

         1          0          1          0          0          0          0
                 0.00       1.00       0.00       0.00       0.00       0.00

         4          0          0          1          0          0          0
                 0.00       0.00       1.00       0.00       0.00       0.00

         5          0          0          1          0          0          0
                 0.00       0.00       1.00       0.00       0.00       0.00
```

Figure 5

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```
      ∇INITIALIZE[⎕]∇
    ∇ INITIALIZE
[1]   'HOW MANY ITEMS IN THIS SURVEY?'
[2]   Q←⎕
[3]   'WHAT IS THE MAXIMUM NUMBER OF RESPONSES TO ANY ITEM OR QUESTION?'
[4]   'PROVIDE FOR NO RESPONSE, I.E., IF THE EXPECTED RESPONSES'
[5]   'ARE YES OR NO OR NO OPINION; THE CODING IS 1-YES 2-NO'
[6]   '3- NO OPINION 4-NO RESPONSE.'
[7]   P←⎕
[8]   'WHAT IS THE NAME OF THE WORKSPACE?'
[9]   W←⍞
[10]  T←ID←RID←⍳0
    ∇

      ∇START[⎕]∇
    ∇ START
[1]   D←⍳0
[2]   'ENTER THE REPLIES  OF ONE RESPONDENT. TYPE → ON A SEPARATE LINE WHEN FINI
[3]   →3,D←D,⎕
    ∇

      ∇STORE[⎕]∇
    ∇ STORE;V;S
[1]   →((Q=⍴D)∧(∧/D∈⍳P))/L1
[2]   →0,0⍴⎕←'CHECK YOUR DATA. THERE IS AN ERROR.'
[3]  L1:V←(Q×P)⍴0
[4]   S←D+P×0,⍳(Q-1)
[5]   V[S]←V[S]+1
[6]   T←T,V
[7]   'RESPONDENT ';(⍴T)÷Q×P
[8]   'NOW EXECUTE: )SAVE ',W
    ∇

      ∇CHECK1[⎕]∇
    ∇ CHECK1
[1]   →(Q=⍴D)/L1
[2]   →0,0⍴⎕←'YOU HAVE NOT ENTERED THE CORRECT NUMBER OF RESPONSES.'
[3]  L1:'OK'
    ∇

      ∇CHECK2[⎕]∇
    ∇ CHECK2
[1]   →(∧/D∈⍳P)/L1
[2]   →0,0⍴⎕←'AT LEAST ONE OF YOUR RESPONSES IS UNACCEPTABLE.'
[3]  L1:'OK'
    ∇
```

Figure 6

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```
      ∇CHANGE[⎕]∇
    ∇ CHANGE;I
[1]   'WHICH ITEM DO YOU WISH TO CHANGE?'
[2]   I←⎕
[3]   'WHAT IS THE NEW VALUE?'
[4]   D[I]←⎕
    ∇


      ∇DELETE[⎕]∇
    ∇ DELETE;I;S
[1]   'WHAT ITEM DO YOU WANT TO DELETE?'
[2]   I←⎕
[3]   S←((I-1)⍴1),(0),(((⍴D)-I)⍴1)
[4]   D←S/D
    ∇


      ∇INSERT[⎕]∇
    ∇ INSERT;I;N;S
[1]   'AFTER WHAT ITEM DO YOU WISH TO INSERT THE NUMBER?'
[2]   I←⎕
[3]   'WHAT NUMBER DO YOU WISH TO INSERT?'
[4]   N←⎕
[5]   S←(I⍴1),(0),(((⍴D)-I)⍴1)
[6]   D←S\D
[7]   D[I+1]←N
    ∇


      ∇RESULTS[⎕]∇
    ∇ RESULTS;CR;S;M;SD;FF;SS
[1]   CR←'
      '
[2]   T←(((⍴T)÷Q×R),Q,R)⍴T
[3]   K←0,FR←⍴0
[4]   'RESPONDENTS  ';1↑⍴T
[5]   CR,CR
[6]  STR:→(Q<K←K+1)/L
[7]   'ITEM         ';K;CR,CR
[8]   F←,+/[1] T[;K;]
[9]   (13⍴' '),(,7 IFT⍳R)
[10]  'FREQUENCIES  ',,7 IFT F
[11]  'PERCENT      ',, 7 2 DFT F÷S←+/F
[12]  M←+/(FF×⍳(R-1))÷SS←+/FF←¯1↓F
[13]  'MEAN         ',, 10 2 DFT M
[14]  SD←(+/(FF×(M-⍳R-1)*2)÷SS-1)*0.5
[15]  'SD           ',, 10 2 DFT SD
[16]  CR,CR
[17]  →STR,FR←FR,F
[18] L:CR,CR,'END'
[19]  T←,T
    ∇
```

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Figure 7

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```
     ∇CROSSATAB[□]∇
    ∇ CROSSATAB;RC;CTV;FR;FRQ;CR;K;I
[1]   CR←'
      '
[2]   T←(((⍴T)÷C×R),C,R)⍴T
[3]  L1:'WHAT IS THE ROW AND COLUMN INDEX OF THE ITEM YOU WISH TO CROSS-TAB?'
[4]   RC←□
[5]   CTV←T[;RC[1];RC[2]]=1
[6]   FR←(CTV)/[1] T
[7]   'AGAINST WHAT ITEMS OR QUESTIONS DO YOU WISH TO COMPARE IT?'
[8]   I←□
[9]   FR←FR[;I;]
[10]  FRQ←+/[1] FR
[11]  PCT←FRQ÷⍉(R,(⍴I))⍴+/+/[1] FR
[12]  CR,'FREQUENCIES',CR
[13]  '      ITEM',(,10 JFT⍳R),CR
[14]  K←0
[15] L2:→((⍴I)<K←K+1)/L3
[16]  (,10 JFT I[K]),(,10 JFT FRQ[K;])
[17]  (10⍴' '),(, 10 2 DFT PCT[K;])
[18]  CR,CR
[19]  →L2
[20] L3:CR,CR,'DO YOU WISH TO PERFORM ANOTHER CROSS-TAB?'
[21]  →('Y'=1↑T)/L1
[22]  T←,T
     ∇
```